Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

COMMENTS OF

GENERAL MOTORS CORPORATION
and
GM HUGHES ELECTRONICS

In the Matter of
ET Docket 94-124

SUMMARY

General Motors Corporation ("GM") and its subsidiary, GM Hughes Electronics, file these comments in strong support of the FCC's recent proposal to allocate certain frequencies above 40 GHz for new radio applications, specifically, vehicular collision avoidance radar systems.

Vehicular collision avoidance radar systems offer the opportunity to enhance motor vehicle safety. Such systems will provide drivers with an early alert about potential obstacles or possible collisions in the path of the vehicle.

Collision avoidance radar systems originated in the defense industry. The FCC's proposal to allocate spectrum for vehicular applications of this technology is a major step in encouraging the conversion of defense-based technologies to civilian uses. This encouragement is welcome, and should contribute substantially to the FCC's charter to "generally encourage the larger and more effective use of radio in the public interest."

In these comments, GM strongly supports the proposed allocation of multiple frequencies for vehicular radar. This proposal will enhance competition in the development of improved vehicular radar systems, and encourage manufacturers to try different means for optimizing the tradeoffs between spectrum location and other attributes of vehicular radar systems, such as cost. GM also supports the proposal to treat vehicular radar within the Part 15 (unlicensed) framework, because this framework will maximize opportunities for dissemination of this technology to the public.

GM urges the FCC to complete this rule making as soon as possible, in order to encourage the prompt introduction of this safety technology for the benefit of the motoring public.

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INTRODUCTION

1. General Motors Corporation respectfully submits these comments on its own behalf and on behalf of one of its subsidiaries, GM Hughes Electronics, in response to the Notice of Proposed Rule making ("*NPRM*") (FCC 94-273, released November 8, 1994), in FCC ET Docket 94-124. For almost a decade GM automotive engineers have been actively exploring the use of millimeter wave radars to warn drivers about obstacles in front of their vehicle. These efforts have been part of a larger GM activity to explore more fully how the advances in electronics and communications can benefit GM's customers specifically, and the American driving public in general.

2. In this effort, GM has also called upon the electronic engineering expertise of its wholly owned subsidiary, GM Hughes Electronics. Two key subsidiaries of GM Hughes Electronics--Delco Electronics ("Delco") and Hughes Aircraft Company ("Hughes") have been actively engaged in exploring the uses of millimeter radars for vehicles. Delco is the world's leading manufacturer of automotive electronics, producing more automotive computers and OEM car radios than anyone else. Hughes is a major developer and manufacturer of sophisticated communications equipment, including many high performance radar systems used by the U.S. Defense Department.

3. Hughes and Delco have centered their efforts on vehicular radar within HE Microwave ("HEM") which is jointly

owned by Hughes and Delco. HEM's development of vehicular radars is supported by the automotive electronics expertise of Delco and the radar system expertise of Hughes. Delco is currently marketing HEM's school bus FOREWARN™ obstacle detection system. This system operates at 10.5 GHz and provides supplemental warning to a school bus driver about obstacles that may be immediately in front of the school bus and in front of the back right wheel when the bus is stopped and the "Stop Arm" is out. Development is nearly done on a FOREWARN™ side obstacle detection system for the rear of commercial trucks. Both of these radars will operate at 24.125 GHz.[1]

GM Efforts in Millimeter Wave Vehicular Radars

4. GM has been actively exploring the technical challenges of using millimeter wave radars to warn drivers about obstacles in front of their automobiles for almost a decade. Efforts in the mid '80s were centered around defining the technical and human factors considerations of a forward radar system. A highly instrumented van was built to allow for simultaneous recording of video and radar sensor data to allow for careful correlation between the radar sensor inputs and the actual traffic events. In addition, sophisticated driving simulators were used to evaluate the human factors considerations and to evaluate

[1] Operation of all three systems is (will be) pursuant to §15.245 of the Commission's rules.

alternate methods of presenting the radar system outputs to the driver.

5. Based on the considerations developed from these efforts, GM and Hughes built and field tested a 60 GHz test radar in 1989. Evaluation of this unit showed that increasing the frequency would be necessary to fully meet the size requirements of the automotive industry. GM and Hughes in 1994 built and field tested a redesigned unit operating at 76 GHz. As discussed below, 76 GHz was chosen because it offered an excellent trade-off of antenna size and component costs with the additional benefit of the possibility of exporting units to the European market, since the 76-77 GHz had already been chosen as the band for European forward vehicular radars. GM and Hughes (using HEM) are ready to begin testing of a second generation 76 GHz radar.

6. Based on this development work, GM filed a Petition for Rule making (RM-8308) on July 13, 1993 asking for authorization of vehicular radars at 76-77 GHz. Subsequent discussions with other members of the American Automobile Manufacturers Association ("AAMA") and its members' suppliers have resulted in a joint industry request for authorizing additional frequency bands.[2] GM fully

[2] In addition to GM, Ford Motor Company and Chrysler Corporation are members of AAMA.

supports the position presented in the AAMA Comments that are also being filed today.

7. GM commends the Commission for issuing this *NPRM* in response to the GM rule making petition. The Commission's proposal is a necessary and valuable start toward enabling the American driving public to benefit from the advances in millimeter wave technology.[3] GM urges prompt action by the Commission to issue a final decision allocating frequencies for vehicular radars in order to expedite the marketplace introduction of this safety technology.

8. GM fully supports the key allocational decisions made in the *NPRM* with respect to vehicular radars. The decision to authorize multiple frequency bands with open entry under the Part 15 (unlicensed) framework is valuable and will enable American drivers and concerned government agencies to explore different trade-offs and benefit from the competitive environment the Commission's decision will promote. The one area where GM feels the allocational proposals in the *NPRM* can be improved upon is in the proposed band above 100 GHz. Careful discussions between the members of AAMA and some of their suppliers had resulted

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[3] While GM recognizes, and applauds, the NPRM's contribution toward promoting the use of millimeter wave technology, these comments address only those issues related to vehicular radar. We are aware that Hughes Aircraft Company, Communications Products Business Unit, is filing separate comments that address issues related to licensed and general unlicensed devices.

in a consensus that substituting 152 GHz for 139 GHz would benefit the development of advanced vehicular radars in the future and should not disadvantage the licensed and general unlicensed services. As shown below, GM and AAMA also believe that expanding the above 100 GHz allocation bandwidth to 2 GHz will yield significant cost savings to drivers and should be implemented.

9. A careful review by GM's engineers of the proposed technical standards has raised several areas where changes would be valuable in allowing the public to obtain the full benefits of this technology. The rationale for these suggested modifications are fully presented below. In summary, the desired changes are as follows:

- Increases in the allowed power levels.
- A slight relaxation of the proposed restriction on side lobe pattern (although GM notes that even without an explicit FCC restriction, manufacturers must significantly restrict side lobe emissions to obtain adequate performance).
- Out-of-Band emission suppression requirements of 72 dB are far in excess of what is needed, what can be economically built, and what can reasonably be tested. GM recommends that they be reduced to 25 dB.

- Some minor adaptions of the FCC's traditional measurement procedures to the characteristics of millimeter waves would significantly reduce the regulatory burden of the FCC's test procedures. Included are explicitly allowing separate transmitter and antenna measurements (in lieu of combined radiated measurements) where possible and eliminating the need to needlessly search through frequencies where no emissions are possible.

PUBLIC INTEREST IN VEHICULAR COLLISION AVOIDANCE RADARS

The public interest will be well served by the introduction of vehicular collision avoidance radar systems. These systems are designed to enhance motor vehicle safety by providing an alert to a motor vehicle driver about obstacles or potential collisions in his path.

Vehicular collision avoidance radar systems are an important component of the Intelligent Vehicle-Highway System (recently renamed the Intelligent Transportation System, or ITS). The ITS is a comprehensive program with partners in government and industry exploring ways to improve the interaction between motor vehicles and highways. The potential benefits of ITS programs include safer highways, less congested highways, improved information for drivers and public safety officials, among other benefits.

A vehicular collision avoidance radar system will inform a driver about potential collisions in his path, in an effort to allow him time to take accident avoidance maneuvers, such as applying his brakes or steering to avoid the obstacle. Public benefits from these systems include the potential for reduced accident involvement, which should in turn lead to fewer injuries, less property damage, reduced insurance premiums for consumers, lower state/local government costs for emergency medical personnel and other substantial public benefits.

GM notes that the vehicular collision avoidance radar systems it contemplates for commercial introduction in the near term are driver alert systems, limited at first to providing information to drivers, and subsequently to offering an enhanced cruise control system to help maintain speed dependent distance between vehicles. The near term systems do not contemplate any interaction with the vehicle brake system, nor do they contemplate any automatic steering inputs. Thus, the driving public should find vehicular radar systems easy to use, building on familiar systems within the motor vehicle. GM understands that the National Highway Traffic Safety Administration is evaluating driver interaction with vehicular radar systems as part of its comprehensive safety research programs.

ALLOCATION ISSUES

10. GM commends the Commission for its treatment of the various spectrum allocation issues raised in the *NPRM*. The *NPRM* wisely proposes that the vehicular radar bands be open to all users that meet the power restrictions and other technical requirements. The allocation of multiple frequencies is likewise important to allow different vendors to approach the complicated technical tradeoffs in different ways and to allow room for future advances in technology. With the exception of the above 100 GHz allocation (discussed below), we believe the *NPRM* wisely allocates appropriate bandwidth. With respect to the allocation above 100 GHz, GM strongly supports the AAMA position that the vehicular radar band should be at 152.0-154.0 GHz, using the 139.0-140.0 GHz band for licensed and general unlicensed activity.

Separate Vehicular Radar Bands Open to All Users Are Appropriate

11. In the *NPRM* the Commission recognizes that vehicular radar use does not need to be exclusive to any one user or other party. Rather, the most efficient usage of the spectrum will be promoted by allowing vehicular radar to operate under the Part 15 Unlicensed Framework. All applicants who can meet the technical requirements, especially the power limit, should be allowed to sell their equipment, without the need for any further FCC licensing requirements. This "open entry" policy is especially

valuable for two reasons. First, it makes it easier for drivers to benefit from an open market in which a wide variety of technical approaches are potentially available. Second, it reduces the transactions costs that would significantly interfere with the introduction of vehicular radars to the driving public.

12. As discussed earlier, the use of vehicular radars is just in its infancy. As is usual in such situations there are a wide variety of technical alternatives available to potential manufacturers of this equipment. The best thing the FCC can do at this point is to allow manufacturers to utilize a wide variety of approaches and let the resulting experience determine which are the best approaches. Given that the current applications for vehicular radars are limited in scope, the FCC's approach of allowing these multiple technical approaches with minimal restrictions is appropriate.

13. Further, we believe manufacturers will choose systems that have very high resistance to interference from other car radars. Certainly, the approach of HEM, based on use of Frequency Modulated, Continuous Wave (FM-CW) radar, provides a high degree of protection from interference as discussed in Appendix A. While the HEM system does include some proprietary features, there is nothing proprietary about the approach discussed in Appendix A. The proprietary features merely add performance and interference immunity

beyond that provided by the system discussed in Appendix A. Given the ready availability of radar designs with such high levels of interference rejection, it is very unlikely that any manufacturer would deliberately choose a system that did not provide adequate interference rejection.

14. As the *NPRM* correctly notes in ¶14, there are circumstances where the most efficient use of the spectrum is achieved by simply allowing all users who meet the technical standards to sell their equipment. The allocation of unlicensed Part 15 bands for use by vehicular radars is one of those circumstances. First, the high potential public benefits of vehicular radars warrant the allocation of spectrum for this important use. Further, the technical nature of vehicular radars means that there is no limitation upon the number of vehicles that can use these radars. Allowing one driver, or even one manufacturer, to use a vehicular radar does not in any way prevent another driver, or manufacturer, from also using the same frequency band for vehicular radars. As the *NPRM* correctly points out, any entry price would tend to reduce usage in the band (the "public goods" model).

15. Worse, most of the benefits of any form of entry pricing would be "wasted" in transactions costs. Clearly, any form of traditional licensing would entail significant transactions costs to all concerned, including the FCC. The idea of having to issue a license to every driver using a

vehicular radar is daunting. Issuing licenses to radar or car manufacturers would be equally difficult, since neither party has any control over the radar unit once it is sold. Any attempts to "sell rights" to use vehicular radars would be subject to significant transaction costs. Even ignoring the deleterious effects on efficiency from any entry barrier on a "public good," there is a concern that the holder of these rights may also be motivated by market control motives, rather than simply insuring a return on its investment in spectrum. On a related point, GM commends the Commission for recognizing that spectrum allocation for vehicular radar systems is an inappropriate candidate for spectrum auction. Indeed, GM submits that spectrum auction for vehicular radar systems would be inconsistent with the statute authorizing limited use of spectrum auctions, primarily because the spectrum allocation for vehicular radar systems should be open to any potential user. As such, it is therefore inappropriate for the limited, exclusive allocation that is inherent in the auction concept.

16. At ¶29, the *NPRM* proposes to authorize only vehicular radar use in the bands proposed.[4] In particular,

[4] The *NPRM* does note, however, that amateur and amateur-satellite services are already authorized on a secondary basis in the 76.0-77.0 GHz band [*See* §§2.106, 97.207(c)(1), and 97.301(a) of the Commission's Rules]. Further, the *NPRM* proposes (at ¶21) to implement in the U.S. Table of Allocations [§2.106], the decision of WARC-92 to add a secondary allocation of Space Research (space-to-earth) to the band 76-81 GHz. GM believes

the *NPRM* chose not to propose sharing of the vehicular radar bands with either the licensed services or general unlicensed devices. GM believes that this is the correct decision. While, as discussed below, GM believes that sharing under carefully controlled circumstances is possible, we believe that sharing with the licensed service identified in the *NPRM* or general unlicensed devices would be inappropriate.

17. Under the proposal in the *NPRM*, the licensed bands would be auctioned off on the basis of Major Trading Areas. This application would not be appropriate for sharing with vehicular radar bands. First, under the general Commission provisions for unlicensed Part 15 devices [§§15.5(c)m 15,17], the auction winner would be under no obligation to prevent interference to vehicular radars. Second, having paid out substantial sums for the use of the band, the winners would be under powerful economic incentives to maximize the use of their band, at the expense of vehicular radar use. These conditions would simply be unacceptable, and the Commission was correct in not proposing sharing with licensed services in the *NPRM*.

18. Sharing the vehicular radar bands with general unlicensed devised would also be unsatisfactory. There is

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none of these services should create problems for vehicular radar usage. In particular, GM does not anticipate that these services will violate the sharing criteria proposed in Appendix B for the 76-77 GHz band.

simply no way to prevent Part 15 devices from being used in circumstances where they might cause interference to vehicular radar operation. For example, some user could install a general Part 15 device on a vehicle. This is especially true if the FCC chooses to raise the allowed power (from the proposed 0.25 W EIRP) as discussed in ¶40.

19. As proposed in the *NPRM*, vehicular radars would share the proposed bands with (Federal) Government radars. GM has carefully studied the issue of frequency sharing. While any vehicular radar that GM would use would be carefully designed to reduce its susceptibility to interference, it is simply impossible to design any economically feasible car radar to be immune to any potential interference. Instead, there needs to be a carefully developed criteria for sharing a band between vehicular radars and government radars. In Appendix B, GM proposes a sharing criteria for the 76-77 GHz band.[5] Since only public highways needs to be protected from Government radar interference, the sharing criteria developed for the 76-77 GHz band will allow significant opportunities for the Government to utilize the band.

20. As discussed above, the *NPRM* correctly proposed the most appropriate model for the allocation of vehicular radar bands, the open entry approach of Part 15. This will

[5] While GM is not in a position at the present time to provide detailed proposals for other bands, we are confident that they can be developed.

allow multiple manufacturers to supply the needs of the driving public without any artificial limitations on technology or entry. The *NPRM* correctly determines that the vehicular radar bands should not be shared with the licensed service nor general Part 15 devices. Any sharing with Government radars should be in accordance with the sharing criteria proposed in Appendix B.

Importance of Multiple Frequencies

21. The *NPRM* correctly proposes to allocate multiple frequency bands for vehicular radar bands. Given the demanding technical requirements on vehicular radars, including the necessity for carefully balancing the needs for small antenna size and the narrow beamwidths required to meet performance requirements, different manufacturers will make different trade-offs and utilize different frequency bands. Given the significant benefits to the driving public from these radars, it is important to allow both the public and concerned government agencies to test the different trade-offs that occur. Multiple frequency bands will encourage the maximum amount of competition between different manufacturers.

22. GM believes that it is particularly important that the 76-77 GHz band be among those allocated. Based on the development work of GM's HEM subsidiary, GM believes that this band is a particularly good trade-off of microwave device costs and antenna size. In addition, its selection

by the European development consortium for vehicular radars in Europe provides additional benefits to American drivers and American manufacturers. Drivers will benefit from the increased economy of scale due to its widespread use in both Europe and America. American manufacturers will benefit from the easier entry into European markets since the same frequency band will be useable in both the US and Europe.

Substitution of 152 GHz for 139 GHz

23. The original AAMA submission in this docket proposed that two bands above 100 GHz, each of 2 GHz bandwidth, be allocated for future vehicular radars. As explained in ¶30 the Commission was concerned about the justification for two bands of 2 GHz each. Instead the *NPRM* proposed only one band above 100 GHz, 139-140 GHz. After detailed discussion among the three domestic automobile manufacturers and their suppliers, AAMA has reached the conclusion that it would be preferable to allocate the 152 GHz band for vehicular radars and utilize 139 GHz for licensed and general unlicensed bands. As discussed below, AAMA also believes that a 2 GHz bandwidth should be allocated at 152 GHz. GM strongly supports this recommendation.[6]

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[6] Formally, GM proposes that the following allocations above 130 GHz be made.

139.0-139.5 GHz	Licensed
139.5-140.0 GHz	General Unlicensed
152.0-154.0 GHz	Vehicular Unlicensed

24. The basis for the recommendation to allocate 152 GHz rather than 139 GHz is that the quickest and most economical way to utilize frequencies above 100 GHz for vehicular radars is to use doubling technology. With doubling technology, the signal is created at ½ the radiated frequency and then "doubled" before it is radiated. The proposed 152 GHz vehicular band is twice the 76 GHz band, while there is no convenient relationship between the 139 GHz band and any vehicular band. Thus, allocation of 152 GHz for vehicular radar use in lieu of 139 GHz will allow earlier and more economical use of above 100 GHz frequencies for vehicular radars.

25. GM does not believe that the licensed and general unlicensed bands will be disadvantaged by our proposed substitution. The bandwidth available to both other uses will be unchanged. In general, it should be more economical for the licensed and general unlicensed devices to use the lower frequency of 139 GHz instead of 152 GHz, since neither frequency is a doubling of a lower licensed/general unlicensed band.

Bandwidth Considerations

26. The *NPRM* proposes allocations for vehicular radars at 76.0-77.0 GHz and 94.7-95.7 GHz, but asks (at ¶30) for "[m]ore specific information on . . . the amount of spectrum required in each band." GM believes that the need for 1,000 MHz bandwidth at 76 and 94 GHz is justified by (1) the

significant reduction in the probabilities of interference between units,[7] and (2) the need to reduce costs of manufacture because of the large public benefits from the availability of forward-looking vehicular radars to the public.

27. In order to help quantify the cost savings from allowing an adequate bandwidth at 76 and 94 GHz, Nicholas Morenc, Technical Manager for HE Microwave (owned by GM subsidiaries Delco Electronics and Hughes Aircraft Company), analyzed the existing production statistics for the 10.5 GHz (X-band) FOREWARN(™) obstacle detection system for school buses sold by Delco Electronics. In addition, Mr. Morenc talked to existing producers of the 10.5 GHz MMICs, anticipated producers of devices at 76 GHz, and parts of Hughes Aircraft Co. that were contractors to the Defense Department on the Microwave/Millimeter Wave Monolithic Integrated Circuits Program.

28. Based on his analysis, discussions, and his own 27 years of experience in designing and constructing radar modules, Mr. Morenc computed relative costs of the X-band module (i.e. the entire radar sensor) for the FOREWARN(™) school bus program based on the percentage bandwidth available and estimated the corresponding costs at W-band (76 GHz). For reference, the available percentage bandwidth

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[7] Appendix A presents a quantitative modeling of this effect for FM-CW radars at 76 GHz.

at the Part 15 X-band is 0.5%, 1.0% at the Part 15 Ka-band (24.125 GHz), and the proposed bandwidth at 76 GHz in the *NPRM* is 1.3%.

29. These cost estimates, as a function of percentage bandwidth, are as follows:

% Bandwidth	Module Cost Impact X-band Actual	Module Cost Impact W-band Projected
0.5%	+26%	+49%
1.0%	+10%	+20%
1.5%	Baseline	Baseline
2.0%	-7%	-9%

Since the estimates were done in 0.5% increments of bandwidth, the 1.5% bandwidth case was taken as the baseline, since it comes closest to the 1.3% bandwidth proposed in the *NPRM* for W-band. Thus, the estimate is that decreasing the proposed bandwidth at 76 GHz to 1% would raise the estimated cost of the radar sensor by 20%.

30. These cost estimates are based on 100% inspection of frequency over temperature. Mr. Morenc believes that these cost estimates probably underestimate the cost penalty for decreasing the bandwidth below the 1 GHz proposed in the *NPRM*, since the proposed 1 GHz bandwidth may make it possible to reduce the amount of production line testing below the 100% that would certainly be necessary with any significant reduction in allowed bandwidth at 76 GHz.

31. Based on this cost analysis, GM believes that the *NPRM* was correct in proposing 1 GHz for the 76 & 94 GHz vehicular bands. While we understand the basis of the FCC's concern about allocating a 2 GHz band for use above 100 GHz, we believe that the cost savings to American drivers would be significant. The same cost analysis work is also relevant to considering the impact of bandwidth at 152 MHz, since as discussed above, the best way to produce 152 GHz vehicle radars will be to construct a 76 GHz system and then double the frequency. However, there is one other factor that needs to be analyzed to assess the impact on costs of the allowed bandwidth. In the analysis presented above, the assumption is that the actual modulation bandwidth is relatively small in comparison to the allocated bandwidth.[8]

32. In the more advanced vehicular radar systems that will use frequencies above 100 GHz, significantly larger

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[8] For example, the HEM system under design for 76 GHz has an actual modulation bandwidth on the order of 100 MHz.

modulation bandwidths will be required. This increased modulation bandwidth is driven by the need to operate at longer range, tighter angular resolution, and tighter range resolution. These improved performance requirements are the result of the need to track targets through curves, provide adequate time for complete braking at limited access highway speeds, and provide for the highway convoy considerations currently being defined for ITS by IVHS America and the Federal Highway Administration. It is anticipated that modulation bandwidths of about 600 MHz will be required.

33. A modulation bandwidth of 600 MHz at 152 GHz will require that the 76 GHz (W-band) device have a modulation bandwidth of 300 MHz. This reduces the allowable frequency variation within 1 GHz from 1.3% [1.0/76.5] to 0.9% [(1.0-0.3)/76.5]. Neglecting the higher component cost for 152 GHz components, conservative estimates for the cost impact of higher modulation bandwidths becomes as follows:

Modulation Bandwidth	FCC Allocated % Bandwidth 152.5 GHz	FCC Effective % Bandwidth 152.5 GHz	Module Cost Impact W-band Projected 1 GHz BW	Module Cost Impact W-band Projected 2 GHz BW
0 MHz	0.658%	0.658%	Baseline	Baseline

200 MHz	0.658%	0.525%	+47%	+14%
400 MHz	0.658%	0.393%	+65%	+27%
600 MHz	0.658%	0.262%	+95%	+48%

Thus, allowing the allocation of 2 GHz at 152 GHz should lower module production costs by 50% [48%/+95%]. Given the significant number of vehicular radars that will be used, GM believes this significant cost reduction justifies the allocation of the larger bandwidth at 152 GHz.

34. GM recognizes that the Commission did not have the benefit of these detailed cost estimates when it issued the *NPRM*. These cost estimates, based on actual production experience, provide a sound basis for assessing the impact on American drivers of the allocated bandwidth. They clearly establish that the proposed allocation of 1 GHz at 76 & 94 GHz is appropriate and that the public interest would clearly be served by increasing the allocated bandwidth above 100 GHz to 2 GHz, i.e., 152.0-154.0 GHz.

Need for Quick Action on a Final Decision Authorizing Vehicular Radars

35. As discussed above, GM has been working on vehicular millimeter wave radars for almost a decade and invested millions of dollars and hundreds of person-years of engineering effort into developing these radars as a product to benefit the American driving public. The efforts of GM,

its subsidiaries, its automotive competitors, and other potential suppliers have progressed to the point where actual product decisions need to be made in the near future. Without rapid Commission action on a final decision authorizing millimeter vehicular radars, GM and others will be forced to delay making the final commitments to begin the process of integrating the test systems available today into production vehicles.

36. By the standards of the personal computer and consumer electronics industries, the product cycles in the automotive industry are extremely long. This results from the need to integrate and thoroughly test any new electronic device with all of the other components of a vehicle. To incorporate a forward radar into a model year '98 vehicle program, the design must be fixed in '96. This clearly cannot occur until after the FCC has issued a final decision authorizing millimeter vehicular radars. GM was gratified to note in the *NPRM* (footnote 6 to ¶6) that the Commission "may later choose to act on these issues separately if doing so would expedite the implementation of vehicular radar systems." GM urges the Commission to proceed with those plans if prompt action on the rest of the issues in this Docket is not possible.

TECHNICAL ISSUES

37. A detailed review by the GM engineers involved in developing and testing millimeter vehicular radars have